J Forensic Sci, July 2007, Vol. 52, No. 4
doi: 10.1111/j.1556-4029.2007.00458.x
Available online at: www.blackwell-synergy.com

TECHNICAL NOTE

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Failure of Anthropometry as a Facial Identification Technique Using High-Quality Photographs*

ABSTRACT: Anthropometry can be used in certain circumstances to facilitate comparison of a photograph of a suspect with that of the potential offender from surveillance footage. Experimental research was conducted to determine whether anthropometry has a place in forensic practice in confirming the identity of a suspect from a surveillance video. We examined an existing database of photographic lineups, where one video image was compared against 10 photographs, which has previously been used in psychological research. Target (1) and test (10) photos were of high quality, although taken with a different camera. The anthropometric landmarks of right and left ectocanthions, nasion, and stomion were chosen, and proportions and angle values between these landmarks were measured to compare target with test photos. Results indicate that these measurements failed to accurately identify targets. There was also no indication that any of the landmarks made a better comparison than another. It was concluded that, for these landmarks, this method does not generate the consistent results necessary for use as evidence in a court of law.

KEYWORDS: forensic science, forensic anthropometry, facial identification, image comparison, identification

Anthropometry is a term used to describe the study of measuring the human body for anthropological comparison and classification. Alphonse Bertillon transformed the French criminal justice system in 1882 when he implemented a method of criminal identification using anthropometry, calling the technique *Bertillonage*. Moenseen states in his book, Fingerprint Techniques (1), that "Bertillon's system of anthropometrical measurements was based on three fundamental ideas: the fixed condition of the bone system from the age of twenty until death; the extreme diversity of dimensions present in the skeleton of one individual compared to those in another; the ease and relative precision with which certain dimensions of the bone structure of a living person can be measured using simply constructed calipers." Bertillon came up with a classification consisting of 11 measurements including height, length and width of head, arm span, sitting height, length of left middle and little fingers, length of left foot, length of left forearm, length of right ear, and width of cheek (2).

More recently, anthropometric measurements have been used to compare the body types of pedophiles and rapists (3), but they have also been used to identify possible crime suspects by comparing photographs and living persons, as in the case studies presented by Halberstein (4). He used head length and head height along with other landmarks in three case studies in which he compared measurements from photographs of a perpetrator against measurements from the live suspect. Morphological comparisons, in addition to the anthropometric proportions, were used to assist in identification, resulting in convictions in two of the three case studies mentioned and an acquittal in the third case.

The process of obtaining measurements from photographs is called photogrammetry. There are advantages to obtaining measurements from a photograph as opposed to a living person; for example, cooperation from the individual is not required (5) when measuring a living person, his or her assistance is needed in staying still for long periods of time, which can be especially difficult for children (6). On the other hand, landmarks may be more evident and identifiable on a living person rather than a photograph (7).

The photographs designated for comparison must be large enough to locate the landmarks that are to be used. In cases where it is necessary for one or both of the photographs to be enlarged, Porter and Doran measured interpupillary distance as a way to ensure that the correct magnification was produced (8). In their research they took three photographs of the same subject who had different hair lengths and amounts of facial hair, and used measurements, such as the horizontal face width between ear attachments to the face, to determine if the person in the three different photographs was the same. Their outcome was successful in concluding that there are certain statistical tests that can help determine the probability of the photographed individuals being the same person. In contrast, experiments performed by Catterick (9) have shown there to be a "limited discriminating power of facial measurements based on four features." The features tested were ratios of measurements between the eyes and nose, and eyes and mouth, as well as measurements between the eyes and chin and the eyes and mouth.

Using a comparison of facial anthropometric measurements may be especially helpful in cases involving comparisons of a suspect's photograph and surveillance crime footage of the offender. The government in the United Kingdom uses video surveillance systems to prevent crime and to monitor high-risk areas. However, many video surveillance systems used produce images that can be of poor quality and not easily recognizable. This is a fundamental problem

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*Presented at the 17th Meeting of the International Association of Forensic Sciences, August 2005.

Received 6 Nov. 2005; and in revised form 1 April 2006, 15 Sept. 2006 and 30 Dec. 2006; accepted 31 Dec. 2006; published 24 May 2007.

as shown in a case described by Ventura et al. (10). They describe a case where an anthropometric comparison could not be carried out because of the quality of videotape portraying the offender. In video surveillance systems that use VHS tapes, the tape may be constantly reused to save money, which, over time, causes the images to degrade. Analog video systems are limited to a certain resolution, beyond which enlarging a portion of the image will not add any additional detail (11). At present, more organizations are switching to digital systems, which have distinct advantages and disadvantages. Advantages include better quality images and the ease of using the system. An important disadvantage occurs when the images are exported: they are compressed and essential detail may be lost.

To obtain the most constructive information from surveillance cameras, one must be clear about the objectives in setting up a surveillance system. Placement of cameras depends on the intention either to concentrate on preventing employees from stealing or to provide security for employees and customers from potential offenders. Cameras placed at high angles will not necessarily give the detail needed for identification; however, cameras placed at low angles run the risk of the view being blocked (12). The type of lens on the video camera can also affect what is captured on videotape. A wide-angle lens may allow a large amount of area to be seen but can also distort the picture. A telephoto lens, is able to obtain close-up images, but may also affect the image outcome. With so many crimes being caught on surveillance tape, it is important for the images to be clear for a forensic expert's analysis to provide clear-cut evidence in court.

Objective

This study was conducted to test the value of using anthropometric landmarks and proportions to compare images of individuals taken from videotape, and photographs, with the hope of providing accurate evidence for criminal identification in courts of law.

Materials and Methods

A database of photographs of 120 Caucasian male police volunteers were provided by the Department of Psychology at the University of Glasgow, having been used previously in a study by Bruce et al. (13). Images were from the frontal viewpoint, showing features from the neck up. Of those individuals, 80 were shown as video image, and regarded as targets. Photographs of the 120 men were presented in 80 groups of 10 faces in varying sequences, and all were used at least once. In the comparisons of target images with the group of array photographs, it should be noted that its corresponding array photograph was included, thus including persons not present in the video image among the groups of 10 faces. The remaining nine array photographs incorporated were chosen by the authors as if a lineup was being conducted and images of a similar look (facial shape and coloring) were selected.

The images shown in Fig. 1*a,b* were originally used by Bruce et al. (13), with the purpose of testing a person's ability to match faces. Rotation was not the primary issue when recording the target images. One limitation, therefore, in the present study is that some of the images were slightly rotated to the left or right by approximately 10° from the frontal position; however, this does more to imitate an actual case scenario, where the photographs will not be taken exactly at the same angle but will be oriented to as similar a position as possible. A positive attribute of these video images is that they were recorded on the same day as the array photographs. This means that there was no possible change in landmark position due to time factors such as weight loss/gain or increase in age. Although the video images are of high quality, especially compared with those from many surveillance camera systems used, occasionally the nose on the video images appeared distorted.

The photographic and video images were analyzed using a measurement program, Facial Identification Centre Version 0.1 © Forensic Medicine and Science, Glasgow University. This program does not situate the landmarks itself, but instead allows the operator to place them, ensuring they are positioned exactly where the operator wishes. The program then computes all linear and angular measurements. Four facial landmarks were chosen (Fig. 2): right and left ectocanthions (A, A′), stomion (B′), and nasion (B). The ectocanthions were positioned on the lateral corner of the eye where the upper eyelid overlapped with the lower lid. The nasion was positioned on the midline of the two ectocanthions on the bridge of the nose. The stomion was positioned on a closed mouth at the midpoint of the vertical facial midline and the horizontal labial fissure (14). Lines were drawn between these landmarks, and a total of six proportion indices (PIs) and six angle values were determined and compared for each subject. As is generally appreciated, proportions, rather than absolute measurements, are used for comparison, allowing the subject sizes to be different in the photographs and taking into account the different media used to produce photographs. PIs were derived by dividing the smaller measurement by the larger measurement and multiplying by 100 and angle values consisted of the measurement of the angle between two specific lines.

Results

Each target image was compared against the 10 array photographs. Results were obtained by finding the absolute value (to ensure a positive integer) of the difference between the PIs of target image and each of the 10 array photographs to determine which PIs from the array photographs were nearest to that of the target. Theoretically, the majority of nearest differences between PIs would be between the video and its matching photograph, hereafter called a "hit" or "match." The differences in PIs between the video image and each of the 10 photographs were then ranked from one to 10. The position for each subject in the six categories was then averaged, and those figures were ranked to determine how close the collections of PIs for each of the 10 array photographs were to that of the target.

After completing the 80 comparisons and analyzing the results, it was observed that there was no consistency leading to any reasonable accurate identification. There was also no indication that any of the landmarks made a better comparison than any other. In Fig. 3 the percentage of hits or matches of the 80 comparisons that each particular landmark obtained between the video and its photograph for PIs is illustrated. These numbers show that no one specific landmark PI pair produced more matches than any other ($\chi^2 = 2.56$; df = 5, $p = 0.77$). A widespread distribution can be seen and the landmark PI pair that had the most hits was BB′/A′B′ with just 25%. Figure 4 illustrates the percentage of matches between the target video and its test photograph for the calculated angle values. Once again there is a widespread distribution and the angle between the landmarks A′B/A′B′ produced only 22.5% hits. These numbers are also quite low and show that no specific landmark stood out producing more hits than another ($\chi^2 = 2.05$; df = 5, $p = 0.84$). This can be explained by the slight variation in positioning between the photographs and video images.

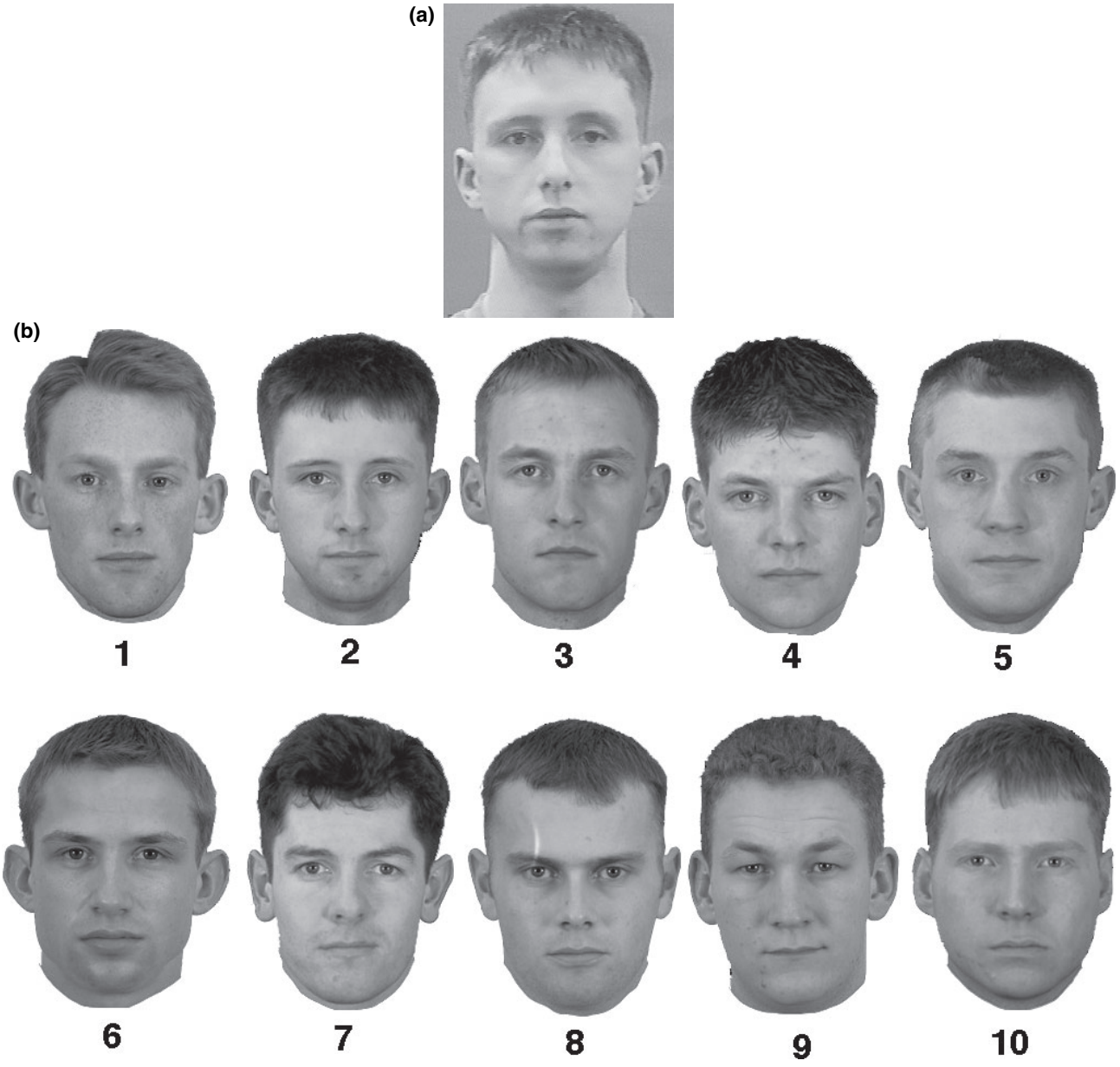

FIG. 1—*(a, b) Example of target image compared against 10 photographs.*

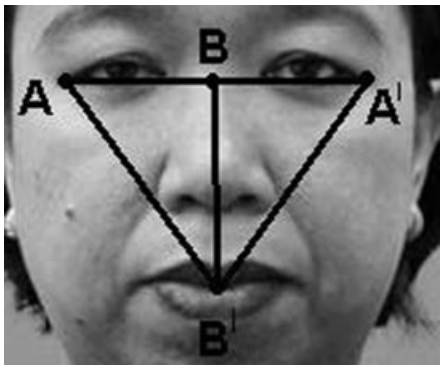

FIG. 2—*Landmarks selected for experiment.*

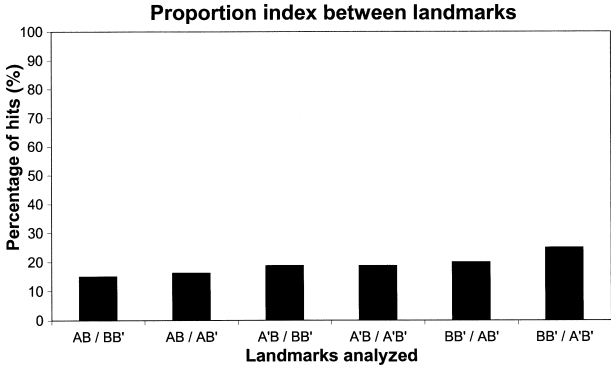

FIG. 3—*The percentage of hits or matches out of 80 comparisons that each particular landmark pair obtained between the video and its photograph for proportion indices.*

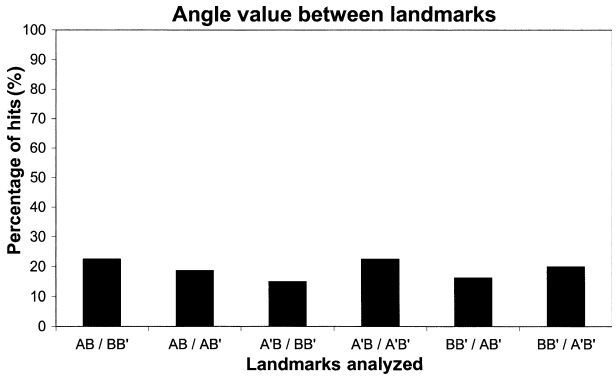

FIG. 4—*The percentage of hits or matches out of 80 comparisons that each particular landmark pair obtained between the video and its photograph for the angles values that were calculated between lines.*

Discussion

Eyewitness testimony can often be the principal evidence resulting in a conviction in court cases, many times condemning an innocent person (15), and should not be the sole evidence in trials. A more scientific method of identification is needed to prove guilt or innocence in the eyes of the court. Wells et al. (15) state that "…eyewitness identification evidence is among the least reliable forms of evidence and yet persuasive to juries." The psychology of facial recognition has been studied for years by researchers and has shown accurate recognition is more likely to result when the target individual is familiar to the witness, even from low-quality images (16,17). However, there is a high error rate when the average person is trying to recognize unfamiliar faces (18). According to Bruce et al. (13) the exactness of facial matching is also decreased with changes in viewpoint, but not as much with changes in facial expression.

Although rapidly improving, the majority of video surveillance equipment often do not produce the clear enough images needed to provide irrefutable identifications. It is in these kinds of cases where anthropometry may be regarded as a potentially useful identification technique. A surveillance tape can be important supportive evidence in criminal cases. Video surveillance may be more reliable than eyewitness testimony because the story it tells is consistent and also corroborates what the eyewitness saw (11). However, a more comprehensive analysis is necessary because even when video images are clear: two people can appear similar or may disguise themselves.

Two people who may appear different but possess similar anthropometric proportions can be readily identified correctly in an identification lineup by witnesses yet, if they were assessed from measurements alone, the results may be misleading. This was the case in one of the experiments conducted, in which two photographs were included in the same series of photographs for comparison against a video and were found to have identical measurements in three proportion indices and three angle values. Yet, on completing a morphological analysis on using a suggested list of characteristics (19), they appeared to have different eye and eyebrow shapes as well as differing mouth and nose sizes.

It was concluded from this research that using facial anthropometry to achieve identification between video and photographic images has limited value when using the chosen landmarks. Photographs have advantages over measuring a living person because it is feasible to go back to the photographs if there is any question about them in the future. It is also possible for several operators to carry out the measurements so as to obtain multiple opinions or to confirm identification. The facial positions of these images were taken in a controlled setting, with video images and photographs positioned as close as possible to a frontal view. It is difficult in actual scenarios to produce two photographs with the exact same positioning. To achieve accurate results, video images compared against photographs should have facial positions and facial expressions that resemble each other. In an attempt to compare images with differing positions, Yoshino et al. (20) developed a 3-D physiognomic range finder that adjusts a 3-D image to match the orientation and size of the 2-D image, incorporating a morphological comparison, an anthropometric analysis, and morphometric matching to achieve facial identification.

It is also more beneficial to compare two photographs separated by a short amount of time, as age and weight changes can affect landmark position and, therefore, the outcome. Other conditions that can affect the comparison are photographs taken under different lighting conditions or differing distances between the individual and the camera (7). Results from the present study show that using these particular landmarks in this type of comparison is neither a reliable nor an accurate enough technique to gather the consistent results necessary for a court of law. It appears from this research that measurements between facial features alone may be insufficient to distinguish between individuals because it is quite possible to obtain small measurable differences even in the same individual taking into account the numerous variables as discussed below that can obtain when such images are produced. Therefore, the possibility of PIs of two different individuals overlapping so that they can appear similar using this methodology is a very real risk.

The concept of using anthropometry as a tool in forensic facial identification is one with intrinsic appeal. However, at stated above, in reality there are too many potentially confounding variables involved to achieve consistent results. Although other researchers have been able to apply varying methods of anthropometric comparisons to cases resulting in convictions (4,8), in this study the ratios and angles resulting from the chosen landmarks have been shown to be of limited use in obtaining identifications. One such important factor that may limit the reliability of anthropometric proportions is changes in facial expression. Research conducted by Purkait (21) cautioned against use of the ectocanthion in comparisons because any minor change in facial expression resulted in inconsistent locations. However, in the research conducted here, it is unlikely to be a factor because unless the person is smiling, the ectocanthion does not appear to move.

Several factors contribute to reservations as to the future use of facial anthropometry from video images from a surveillance system, principally involving the quality of such images. The quality of images is affected by several factors including quality and distribution of lighting, which may create shadows obscuring facial landmarks. Motion blur can also play a significant role in generating poor-quality images. Positions of the head in both images being compared must be the same, and often the position of the surveillance camera does not allow for this. Although the anatomical position of standard landmarks is known, their placement on photographs, even by the most experienced of operators, can be subjective and imprecise when dealing with poor-quality images. Variability in measurements was experienced in Bertillon's time as well with measurements taken by several police officers of one individual because of difficulty in reading minute graduations on the calipers (1).

Our findings suggest that the comparison of video images and photographs using anthropometric proportions from the chosen landmarks, even under nearly ideal conditions, appears to be of

limited value in criminal identification cases. We suggest that future research needs to be focused on biometrics, facial morphological comparisons, and generally improving the quality of images produced from video surveillance systems.

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